Noise Figure Measurement in the 60 GHz Range

Application Note

Products:

- R&S®FSU67
- Noisecom Noise Figure Test Set
  - NC5115-60G
  - NC5115-60GT

This application note describes how noise figure and gain of amplifiers or converters in the microwave range from 50 GHz to 67 GHz are measured. For this purpose the R&S® FSU67 spectrum analyzer is equipped with application firmware R&S® FS-K30 in combination with the Noisecom NC5115-60G, or NC5115-60GT Noise Figure Test Set.

Application Note
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ROHDE&SCHWARZ

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1 Overview

The frequency bands at 60 GHz and above are of increasing interest to the microwave community because of modern technical advances in wireless communications that enable new possibilities. In particular, wireless telecommunication signals in the 57–64 GHz region are subject to oxygen molecule resonance and are severely attenuated, thus limiting their range and allowing several highly directionalized beams within these bands to be broadcast in close proximity to one another without causing interference.

As an example, the WirelessHD™ high-definition signal transmission standard used in consumer electronics products is based on a 7 GHz wide modulation band around a 60 GHz carrier frequency. This allows the transmission of several uncompressed HD video, audio and data signals with rates as high as 25 Gbit/s to be broadcast simultaneously. Other non-commercial applications near the 60 GHz band include satellite to satellite links for secure communications.
The high tech amplifiers and converters used for this technology must be characterized for both noise figure and gain. In the past measuring parameters in this frequency range required complex setups including down conversion with harmonic mixers because of frequency limited measurement equipment. These full band measurements can now be easily made with the R&S FSU67 spectrum analyzer equipped with the FS-K30 noise figure option, and the Noisecom 60 GHz Noise Figure Test Set. This system is designed to perform Y-factor noise figure measurements without the need to down convert your signals.

2 Measurement Setup

The following picture is a schematic of the measurement setup. The spectrum analyzer drives the noise source, the Isolators suppress reflection and improve matching, and an additional preamplifier improves sensitivity of the entire measurement setup.

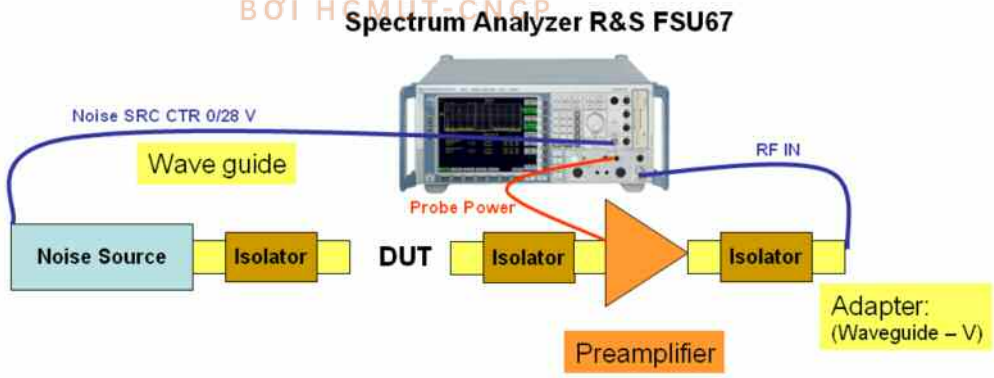

Figure 1: Test setup for noise figure and gain measurement at 60 GHz.

The Noisecom “60 GHz Noise Figure test set” combined with the FSU67 with FS-K30 software is a complete system designed to perform Y-factor noise figure measurements. The test set contains a highly stable V-band noise source, isolators, optional transitions, and a preamplifier. The noise source is factory calibrated at every 1 GHz step to provide additional accuracy. Turning on the bias supply voltage raises the noise source output about 17.5 dB above thermal noise, and is referred to as the

excess noise ratio (ENR). The ratio of thermal noise, T_{cold} (290°K) to T_{hot}, (> 300,000°K typical) in dB is the calculated ENR. The T_{hot} temperature is achieved by supplying bias voltage to the noise source, and the T_{cold} is typical room temperature.

Noisecom Noise Figure Test Set:

- NC5115-60G, WR15 Waveguide
- NC5115-60GT WR15 to 1.85mm coaxial transition for connection to discrete amplifier

System Bandwidth	57 GHz to 64 GHz
System Gain	30 dB typ.
System Flatness	+/- 3 dB
Noise Power Output	17.5 dB typ.
External Amplifier Power Input	3 pin from R&S FSU67 12V, 150 mA typ.
RF Coaxial Connector	Waveguide to Coaxial VT-085 1.85 mm Coax Transition
Calibration Points	1 GHz intervals

To measure the noise figure and gain of a DUT the noise source ENR is used to calculate the Y-factor of the whole system (noise source + DUT + amplifier + analyzer) at the final output stage using a spectrum analyzer. The R&S FSU67 is the only analyzer available, that covers this frequency range without the need for external harmonic mixers (see figure 2).

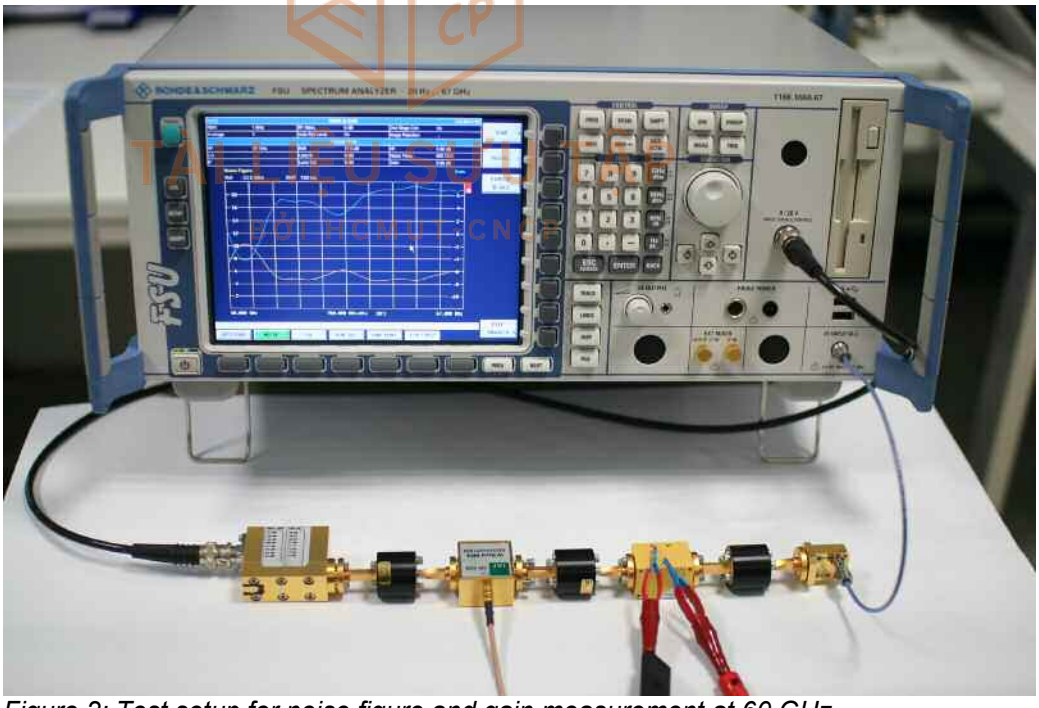

Figure 2: Test setup for noise figure and gain measurement at 60 GHz

3 Measurement of Noise Figure and Gain

To estimate the improvement in sensitivity when using a preamplifier, we compare the noise source output on the spectrum analyzer when the noise source input power is pulsed on, and off. The following picture shows the result. We see a Y-factor of about 9.5 dB at 65 GHz, which results in an overall noise figure of about 8 dB. This means the measured DANL is slightly less than -166 dBm/Hz for the overall setup.

Figure 3: Noise Floor measured with spectrum analyzer R&S FSU67, where ENR output is pulsed on and off.

If the spectrum analyzer includes the FS-K30 noise figure application software all the important results can be retrieved with the push of a button, including controlling the NC5115-60G/T test system. No further calculation or external processing is necessary because the user has defined and saved all the important measurement parameter values in simple table format (see figure 4). System parameters include time, resolution bandwidth, and frequency range or whether the DUT it is a frequency converting device.

To improve the system accuracy it is possible to input the calibrated noise source ENR values to the spectrum analyzer from the supplied cal table. If gain of the DUT is small, the results have to be corrected by the noise figure of spectrum analyzer and preamplifier, which the FS-K30 application software performs automatically when the “2nd stage Correction” feature is selected. During this calibration stage the noise source and amplifier are directly connected via the two isolators without the DUT connected. This calibration procedure only has to be performed once for the same setup and frequency range because the spectrum can be saved as standard trace.

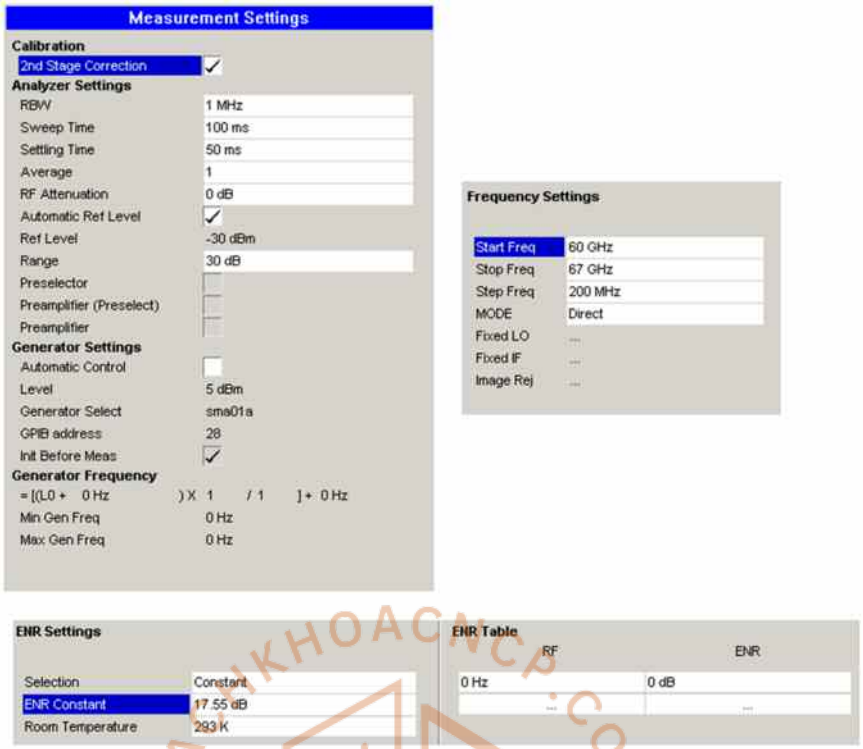

Figure 4: The setup screens for the FS-K30 application firmware are displayed by this simple GUI for measuring noise figure and gain. ENR, frequency range and operation mode can be easily defined.

After the DUT is connected the measurement of noise figure and gain can be started with a simple button press. In this application note the noise figure and gain of a typical microwave amplifier have been measured (see figure 5).

Figure 5: The screen shot displays an example amplifier NF measurement using a DUT designed for W-band applications. The blue trace shows the amplifier gain and the yellow trace is amplifier noise figure.

4 Summary

The R&S FSU67 is the only analyzer available, which covers this frequency range without the need for external harmonic mixers (see figure 1). The instrument can be equipped with the application firmware FS-K30 for measurement of noise figure and gain. The combination with the “60 GHz Noise Figure test set” from Noisecom gives the most powerful system available on the market for measuring noise figure and gain of components in this microwave range. No additional mixers or complex setups are necessary. In addition, users get a fully equipped spectrum analyzer for measurements like output power or signal interference up to 67 GHz. In combination with the preamplifier option, the noise floor of the analyzer drops below -166 dBm/Hz above 60 GHz, providing exceptional sensitivity for detection of spurious emissions within the microwave range.

5 Ordering Information

Rohde&Schwarz

Signal Analyzer and Options

R&S FSU67	20 Hz ... 67 GHz	1166.1660.67
R&S FS-K30	Application Firmware for noise figure and gain	1300.6508.02

Noisecom

Noise figure Test Set

NC5115-60G 57 GHz to 64 GHz WR-15 waveguide
NC5115-60GT 57 GHz to 64 GHz VT-085, 1.85 mm coaxial transition

About Rohde & Schwarz
Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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